ORIGINAL RESEARCH

Feasibility of a Novel Real-Time Provider Teaching Intervention in Acute Exacerbation of Chronic Obstructive Pulmonary Disease

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ABSTRACT

Background: It is not known whether an intervention using real-time provider teaching in acute exacerbation of chronic obstructive pulmonary disease (AECOPD) improves provider knowledge and/or patient outcomes.

Objective: To pilot the combination of a novel, real-time provider teaching intervention delivered by subspecialists to Internal Medicine trainees with a traditional patient education and medication reconciliation (PEMR) intervention and to assess the impact of these interventions on provider knowledge regarding COPD and patient care.

Methods: This was a single-center, nonrandomized, quality-improvement study. Patients admitted with AECOPD were prospectively identified between June 19 and

(Received in original form June 15, 2021; accepted in final form September 14, 2021)

Supported by the National Center For Advancing Translational Sciences of the National Institutes of Health under Award Number UL1TR002384. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Author Contributions: Study design: M.A.S., M.V., M.L.T., D.J.-K., J.K.K., and J.I.L.; data acquisition: M.A.S., M.V., M.L.T., L.D.B., J.K.K., J.S., and M.S.; data analysis and interpretation: M.A.S., M.V., M.L.T., L.D.B., J.K.K., X.W., and J.I.L.; and manuscript drafting and/or revision and final approval: all authors.

This article has a data supplement, which is accessible from this issue's table of contents at www.atsjournals.org.

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ATS Scholar Vol 3, Iss 1, pp 87–98, 2022

DOI: 10.34197/ats-scholar.2021-0077OC

November 20, 2019. Patients with asthma, lung cancer, or interstitial lung disease were excluded. The primary care team received a novel intervention featuring in-person, real-time teaching, covering Global Initiative on Chronic Obstructive Lung Disease COPD groups and management, including pulmonary rehabilitation referral. Providers completed a knowledge assessment before and after their real-time teaching session. Provider knowledge scores before and after teaching were compared using McNemar's test. Patients received a traditional PEMR intervention from a nurse practitioner and/or clinical pharmacist. A retrospective chart review was conducted for 50 historical control patients admitted with AECOPD to obtain preintervention rates of discharge on long-acting bronchodilators and referral to pulmonary rehabilitation. The proportions of patients discharged on long-acting bronchodilators and referred to pulmonary rehabilitation in the intervention group were compared with the preintervention historical control patients using chi-square testing.

Results: Seventy-one providers caring for patients with AECOPD received real-time teaching. Postintervention, there was significant improvement in knowledge scores pertaining to Global Initiative on Chronic Obstructive Lung Disease groups and exacerbation risk (81% correct vs. 43% on pretest; $P < 0.001$) and guideline-directed treatment (83% correct vs. 28% on pretest; $P < 0.001$). Out of 44 eligible patients, 75% ($n = 33$ patients) received the PEMR intervention. Ninety percent of patients ($n = 40$ patients) were discharged on any long-acting inhaler, similar to the group of preintervention control subjects. Pulmonary rehabilitation referrals were made for 50% of patients ($n = 22$ patients) compared with 6% of preintervention control subjects ($n = 3$ patients; $P < 0.001$).

Conclusion: In this single-center quality-improvement study, the combination of a novel, real-time provider teaching intervention and a traditional PEMR intervention improved provider knowledge and was associated with increased referrals to pulmonary rehabilitation.

Keywords:
chronic obstructive pulmonary disease; medical education; real-time teaching; provider teaching

Chronic obstructive pulmonary disease (COPD) was the fourth most common cause of death in the United States in 2019 (1). Frequent exacerbations of COPD lead to reduced health-related quality of life and may accelerate disease progression (2, 3). Given the significant morbidity associated with acute exacerbation of COPD (AECOPD), prevention of future exacerbations is an important part of management.

Hospitalization for AECOPD presents an opportunity for initiation of therapies that can control disease and improve functional status. Pulmonary rehabilitation is a comprehensive, patient-tailored intervention involving therapies such as exercise training, education, and behavior changes. It is distinct from subacute or acute physical rehabilitation (4, 5). Pulmonary rehabilitation can counter the dyspnea-associated deconditioning and loss of exercise capacity associated with hospitalization for AECOPD (6). Long-acting inhalers are recommended for any patient with Global Initiative on Chronic

Obstructive Lung Disease (GOLD) COPD grade C or D disease, which includes all patients admitted to the hospital for AECOPD (4).

Evidence suggests that many patients admitted with AECOPD are not receiving pulmonary rehabilitation referrals or long-acting inhalers on discharge. A recent review of COPD-related admissions found that only half of patients were initiated on long-acting inhalers before discharge (7). In a recent observational study, pulmonary rehabilitation was only received by 1.5% of patients after discharge (8).

Provider teaching interventions are an underutilized tool in addressing the poor adherence to evidence-based practices in patients admitted with AECOPD. Two groups have described provider teaching programs in the outpatient setting. Ulrik and colleagues performed a longitudinal, focused teaching program of 124 general practitioners in Denmark (9). The year-long program included one-on-one educational meetings as well as local symposia discussing GOLD guidelines. The program led to more appropriate prescription of inhaled corticosteroids in simple (GOLD A) COPD. Ferrara and colleagues performed a longitudinal teaching program of 33 Italian general practitioners that involved semiannual, face-to-face teaching sessions with pulmonologists, clinical pharmacists, and other practitioners (10). The teaching program was associated with increased use of spirometry in the diagnosis of COPD rather than a strictly clinical diagnosis.

Neither of the abovementioned studies used real-time teaching, that is, teaching that is conducted at the time of the patient encounter. Miller's pyramid, a commonly used construct in medical education, emphasizes performance and action based on recently acquired knowledge (11). Real-time education has the advantage of being immediately applicable to the clinical situation, potentially allowing optimal performance and action. In a quality-improvement study designed to reduce COPD readmissions, Hopkinson and colleagues used a kiosk providing COPD management teaching to nurses and ward staff while carrying out their clinical duties, which was real time in nature (12). However, in that study, clinical providers were not included in the teaching. To date, no studies have used real-time education of clinical providers regarding COPD.

In summary, it is not known whether an intervention using real-time provider teaching in AECOPD improves provider knowledge and/or patient outcomes. We hypothesized that the combination of a novel real-time, patient-centered provider teaching intervention with a traditional patient education and medication reconciliation intervention would improve provider knowledge and improve receipt of guideline-directed therapy in hospitalized patients with AECOPD. The objective of this quality-improvement study was to pilot test our intervention. Some of our findings were reported in the form of an abstract (13).

METHODS

This single-center quality-improvement study took place at NewYork-Presbyterian/Weill Cornell Medical Center, a tertiary academic center. Project leaders used the Model for Improvement to design a project charter that included a driver diagram to identify areas for improvement in the inpatient and peridischarge care of patients with AECOPD (14). This quality-improvement study was deemed exempt by the Institutional Review Board of Weill Cornell Medicine. There were two

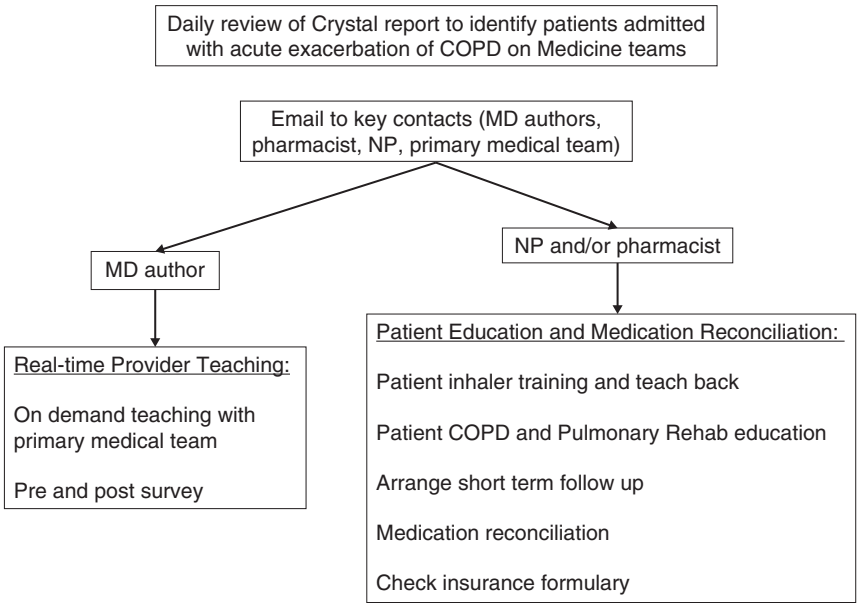

Figure 1. Process map. COPD = chronic obstructive pulmonary disease; MD = medical doctor; NP = nurse practitioner.

simultaneous interventions delivered as part of our study: a novel real-time provider teaching intervention and a traditional patient education with medication reconciliation (PEMR) intervention (Figure 1).

Real-Time Provider Teaching Intervention

Inpatients aged 40 years or older with a diagnosis of COPD exacerbation (International Classification of Diseases code J44.0, J44.1, or J44.9) admitted to the Internal Medicine service were identified daily by one of the authors (J.K.K., M.A.S., M.S., M.T., or M.V.) using Crystal Reports (SAP SE) between June 19 and November 20, 2019. Patients with asthma, active lung cancer, or interstitial lung disease were excluded. When an eligible patient was identified, the Internal Medicine team caring for the patient (including attending physicians, residents, physician assistants, and subinterns) received an email inviting them to a brief teaching session. Teaching was performed by one of the physician authors (J.K.K., M.A.S., M.L.T., or M.V.). The provider team received a 15-minute, face-to-face teaching session designed for Internal Medicine residents by the authors (J.K.K. and M.L.T.) who are pulmonologists. The face-to-face teaching session used a PowerPoint presentation as a visual aid. The session reviewed the GOLD COPD group criteria, appropriate medications based on group, and the importance of pulmonary rehabilitation. All teaching sessions were in real time, that is, conducted during the hospitalization prior to patient discharge.

To gauge improvement in provider knowledge, questionnaires were collected before and immediately after the teaching intervention (*see* Figure E1 in the data supplement). Questions 1–3 were designed to assess knowledge regarding GOLD group and exacerbation risk, and questions 4 and 5 were designed to assess knowledge of GOLD guideline–directed treatment. On the posttest questionnaire, we added two questions (6 and 7) to assess provider attitudes regarding the teaching

session. In addition to these real-time teaching interventions, we distributed a pocket card (Figure E2) to all house staff and physician assistants in the Department of Medicine during the intervention period.

We recorded the number of providers who received the real-time teaching session and the provider attitudes regarding the session as measured on posttest questions 6 and 7. Outcome measures included the proportion of providers answering correctly on questions 1–3 (regarding GOLD group and exacerbation risk) and questions 4 and 5 (regarding guideline-directed treatment) before and after the real-time teaching session.

PEMR Intervention

Simultaneous to our provider teaching intervention, eligible patients were approached by a nurse practitioner and/or clinical pharmacist and offered a brief session (Figure 1). This included smoking cessation counseling, disease-specific education regarding COPD (Figure E3), and information regarding the importance of pulmonary rehabilitation and short-term provider follow up. Patients received medication reconciliation with verification of insurance coverage for inhalers. During this visit, patients were offered a written referral for outpatient pulmonary rehabilitation (Figure E4).

We collected demographics, smoking history, pulmonary function test results (if available), admission medications, and discharge medications. The follow-up appointments in the patient's discharge summary were collected. The patient was considered to receive the PEMR intervention if a nurse practitioner and/or pharmacist documented an educational session with medication reconciliation in the patient's medical record. Outcome measures included discharge on a long-acting inhaler and referral to pulmonary rehabilitation. The patient was considered to have received a referral to pulmonary rehabilitation if the pharmacist or nurse practitioner documented that the patient had received a referral to pulmonary rehabilitation and documented that the patient was willing to attend pulmonary rehabilitation.

The GOLD 2019 guidelines were released after the preintervention historical control patient analysis and before the PEMR intervention started. After the release of the GOLD 2019 guidelines, we added two additional measures in the PEMR intervention population only. First, we measured whether a patient admitted on any long-acting inhaler was also discharged on any long-acting inhaler. Second, we measured whether a patient received an escalation in therapy per the algorithms presented in the GOLD 2019 guidelines—for example, admission on long-acting β-agonist monotherapy but discharge on combined long-acting β-agonist, long-acting muscarinic antagonist, and inhaled corticosteroid (15).

Historical Control Patients

To establish a preintervention historical control group, a retrospective chart review was conducted. Patients were selected using I2B2 software (I2B2 Foundation, Inc.). Inpatients were included if they were aged 40 years or older and admitted from July 1, 2017, to June 30, 2018, with a documented smoking history of at least 10 pack-years and diagnosis of COPD exacerbation (International Classification of Diseases code J44.0, J44.1, or J44.9). Patients with a history of asthma, active lung cancer, or interstitial lung disease were excluded. Using the Allscripts Sunrise electronic medical record (Allscripts

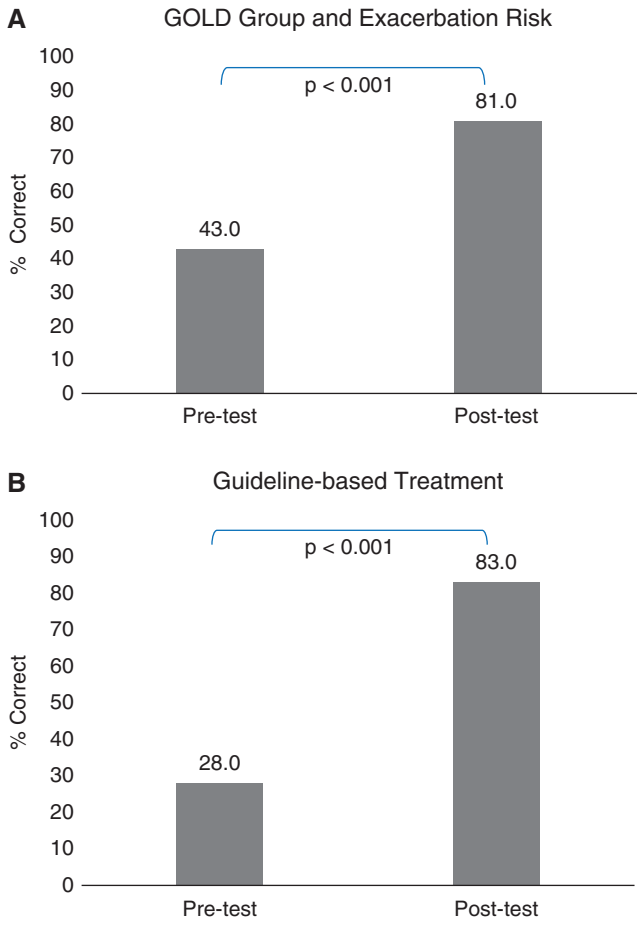

Figure 2. Provider knowledge scores before and after the real-time, patient-centered teaching intervention. (*A*) Questions 1–3, covering Global Initiative for Chronic Obstructive Lung Disease group and risk of exacerbations. (B) Questions 4 and 5, covering guideline-based treatment for chronic obstructive pulmonary disease. GOLD = Global Initiative for Chronic Obstructive Lung Disease.

Healthcare LLC), we collected demographics, smoking history, pulmonary function test results (if available), and discharge medications. The follow-up appointments in the patient's discharge summary were collected.

Data Analysis

For the provider teaching intervention, pre- and postteaching provider questionnaires were examined using frequencies, response rate, and proportion answering correctly. McNemar's test was used to compare the percent answering correctly on questions 1–3 and questions 4 and 5 on the posttest versus the pretest.

For the PEMR intervention, descriptive statistics were generated for demographics. We calculated summary statistics for patient characteristics and outcome measures using frequencies and proportions for categorical variables and means, standard deviations (SDs), medians, and interquartile ranges (IQRs) for continuous variables. Age, smoking pack-years, and postbronchodilator forced expiratory volume in 1 second (FEV_1) were compared with the group of historical preintervention control patients using the two-sample *t* test. Smoking status was compared with the group of historical preintervention control patients using the chi-square test. Hospitalizations within the

past year were compared with the group of historical preintervention control patients using the Wilcoxon rank sum test. Outcomes were compared with the group of preintervention historical control patients using the chi-square test.

All data analyses were performed in SAS version 9.4 (SAS Institute). We set $P = 0.05$ as the threshold for statistical significance.

RESULTS

Real-Time Provider Teaching Intervention

A total of 71 providers received the real-time, patient-centered teaching intervention. Figure 2 shows the results of the pre- and posttests. On the posttest, providers showed improved knowledge on questions 1–3 regarding GOLD group and exacerbation risk (Figure 2A), with 81% ($n = 58$ providers) answering all questions correctly compared with 43% ($n = 31$ providers) on the pretest ($P < 0.001$). Providers also demonstrated improved knowledge of GOLD guideline–directed treatment as measured on questions 4 and 5 (Figure 2*B*), with 83% ($n = 59$ providers) answering both questions correctly compared with 28% ($n = 20$ providers) on the pretest ($P < 0.001$). Individual question-level data are available in Table E1.

When asked whether their knowledge of AECOPD treatment had improved as a result of the session, 63% of providers ($n = 45$ providers) strongly agreed and 33% ($n = 24$ providers) agreed (Figure 3). When asked whether their comfort managing transitions of care in AECOPD had improved, 54% of providers ($n = 38$ providers) strongly agreed and 43% ($n = 30$ providers) agreed (Figure 3).

PEMR Intervention

A total of 44 patients were eligible for our study during the intervention period. Characteristics are given in Table 1. Mean age was 72.4 years (SD, 10.7 yr). Active smokers accounted for 25% of patients ($n = 11$ patients). Mean number of pack-years was 44.6 (SD, 33.9 pack-years). Spirometry was available for 36.3% of patients ($n = 16$ patients). Mean FEV_1 was 49.3% of predicted (SD, 16.9%). Patients had been hospitalized a median of 0 times in the past year for AECOPD (IQR, 0–2 times; $P = 0.01$). This was the only

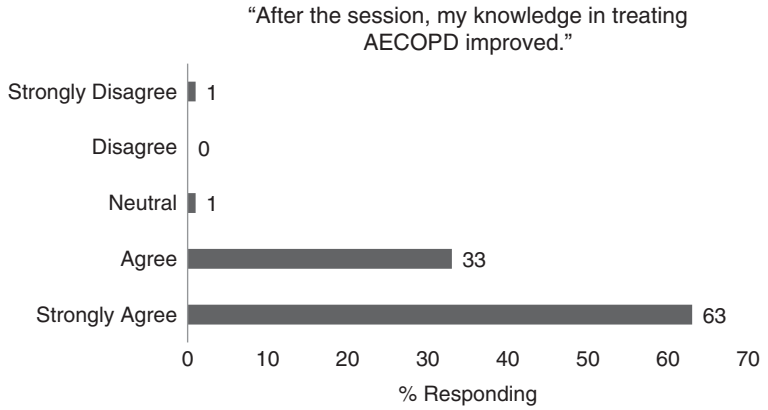

Figure 3. Provider attitudes regarding the real-time teaching intervention, as measured on the postintervention provider questionnaire. AECOPD = acute exacerbation of chronic obstructive pulmonary disease.

Table 1. Patient characteristics

	Total (*N* = 94)	Preintervention (*n* = 50)	Intervention (*n* = 44)	*P* Value
Age, mean (SD)	73.4 (10.3)	74.3 (10.0)	72.4 (10.6)	0.38
Active smokers, *n* (%)	23 (24.5)	12 (24.0)	11 (25.0)	0.81
Pack-years, mean (SD)	47.5 (29.6)	49.8 (25.7)	44.6 (33.9)	0.41
FEV_1, % predicted, mean (SD)	50.8 (17.1)	51.8 (17.4)	49.3 (16.9)	0.65
Hospitalizations in prior year for AECOPD, median (IQR)	1 (0–2)	1 (0–3)	0 (0–2)	0.01
Hospital stay, d, median (IQR)	6 (4–8)	6 (3–9)	5.5 (4–8)	0.72

Definition of abbreviations: AECOPD = acute exacerbation of chronic obstructive pulmonary disease; FEV_1 = forced expiratory volume in one second; IQR = interquartile range; SD = standard deviation.

statistically significant difference between the intervention patients and the preintervention historical control subjects. Median length of hospital stay was 5.5 days (IQR, 4–8 d).

Patient outcome measures are given in Table 2. The PEMR intervention was received by 75.0% of eligible patients ($n = 33$ patients). Any long-acting inhaler was prescribed to 90.9% of intervention group patients on discharge ($n = 40$ patients) compared with 90.0% of preintervention control subjects ($n = 45$ patients; $P = 0.88$). Pulmonary

Table 2. Primary patient outcome measures

	Preintervention (*n* = 50)	Intervention (*n* = 44)	P Value
Discharged on long-acting inhaler, *n* (%)	45 (90.0)	40 (90.9)	0.88
Referred for outpatient pulmonary rehabilitation, *n* (%)	3 (6.0)	22 (50.0)	<0.001
Long-acting inhalers continued*	—	34/35 (97.1%)	—
Step-up in therapy (if not on triple therapy already)*	—	11/25 (44.0%)	—

*These measures were added after the publication of the Global Initiative for Chronic Obstructive Lung Disease 2019 guidelines, after which time the preintervention analysis had already been completed.

rehabilitation referrals were made for 50.0% of intervention patients ($n = 22$ patients) compared with 6.0% of preintervention control subjects ($n = 3$ patients; $P < 0.001$). For the measures performed on the PEMR intervention cohort only after the release of the GOLD 2019 guidelines, 97% of patients (34 out of 35 patients) who were admitted on a long-acting inhaler were discharged on a long-acting inhaler. In addition, 44% (11 out of 25 patients) not already on triple therapy received an escalation in therapy per GOLD guidelines. Patient inhaler classes on discharge are given in Table E2.

Historical Control Patients

Our retrospective analysis identified 50 preintervention historical control patients. Characteristics are given in Table 1. Mean age was 74.3 years (SD, 10.1 yr). Active smokers accounted for 24.0% of patients ($n = 12$ patients). Mean number of pack-years was 49.8 (SD, 25.7 pack-years). Spirometry was available for 50% of patients ($n = 25$ patients). Mean FEV_1 was 51.8% of predicted (SD, 17.4%). Patients had been hospitalized a median of one time in the past year for AECOPD (IQR, 0–3 times). The median length of hospital stay was 6 days (IQR, 3–9 d).

DISCUSSION

In this single-center quality-improvement study, a novel real-time provider teaching intervention combined with a traditional PEMR intervention improved provider knowledge regarding AECOPD and was associated with increased referrals to pulmonary rehabilitation. The rate of referral to pulmonary rehabilitation in the preintervention control patients was 6.0%, which is similar to published studies that have shown pulmonary rehabilitation referral rates ranging from 10–13% (16–18). This number improved to 50.0% of patients as a result of the combined real-time provider teaching and PEMR interventions.

To our knowledge, this is the first study combining a novel real-time provider teaching intervention with a traditional PEMR intervention in AECOPD. Our study supports the feasibility of this approach. Two previously published studies regarding COPD best practices have used provider teaching in the outpatient setting. In the study by Ulrik and colleagues, 124 general practitioners in Denmark underwent a year-long teaching program that included one-on-one educational meetings as well as local symposia discussing GOLD guidelines (9). The teaching program was associated with decreased use of inhaled corticosteroid therapy in patients with simple (GOLD group A) COPD, reflecting increased adherence to guidelines (45% of patients postintervention vs. 75% preintervention; $P < 0.01$) (9). Ferrara and colleagues performed a prospective teaching program of 33 Italian general practitioners that involved semiannual, face-to-face teaching sessions with pulmonologists, clinical pharmacists, and other practitioners. The teaching program was associated with increased use of spirometry for COPD diagnosis and grading (73.0% of patients postintervention vs. 59.7% preintervention; $P < 0.01$) (10). Although these studies showed that provider teaching improved adherence to guidelines in COPD, the providers were not caring for inpatients with an acute exacerbation, and the teaching was not scheduled to align with a patient encounter. That is, the teaching was not real time.

Hopkinson and colleagues performed a quality-improvement study in the

respiratory ward of a London hospital that used admission and discharge bundles (12). The study included patient inhaler training and counseling as well as specialist referral for follow up. In this study, a kiosk was stationed on the medical floor providing education to nurses, and ward staff were invited to observe pulmonary rehabilitation sessions. The number of staff who received education was not reported. Although this allowed for the real-time education of nursing staff, the education did not involve clinical providers (12).

Some studies have used a PEMR intervention only, usually delivered by a specially trained nurse or other staff member. Barker and colleagues performed a quality-improvement study using a patient education discharge bundle that included assessment of inhaler technique, referral for pulmonary rehabilitation and smoking cessation, and follow-up calls with patients. This bundle, when delivered by pulmonary rehabilitation practitioners, led to increased referrals to pulmonary rehabilitation (19). This study did not use provider teaching as part of its intervention. Epstein and colleagues created a clinical decision support tool in the electronic medical record. This tool significantly improved discharge on long-acting inhalers, recommendations for smoking cessation, and arrangement of specialist follow up (20). This study also did not use provider teaching as part of its intervention. It is our hope that future studies regarding best practices in AECOPD will assess for the potential added benefit of real-time provider teaching.

We did not detect a statistically significant improvement in discharge on a long-acting inhaler for our intervention patients compared with the group of preintervention historical control subjects. The rate was 90.9% in intervention patients and 90% in preintervention historical control patients ($P = 0.88$). Both groups of patients were discharged on long-acting inhalers at a rate much higher than that described in previous studies. Amin and colleagues performed an analysis of billing data that showed that only about half of patients admitted with AECOPD were discharged on a long-acting medication (7). In another study of AECOPD examining referral to pulmonary rehabilitation, less than 20% of patients were discharged from the hospital on long-acting bronchodilators (21). One possible explanation for this discrepancy is that our study only included patients with a provider-entered diagnosis of AECOPD and did not include patients with diagnosis codes for related terms such as dyspnea. Provider-entered diagnoses underestimate the prevalence of AECOPD when compared with finalized billing codes (22). A broader approach might be needed to capture all patients admitted with AECOPD, especially those who are undertreated, to ensure they are all discharged on appropriate medication therapy.

Strengths and Limitations

Strengths of our study include the reporting of fidelity to the interventions, as we tracked how many screened patients and providers received the respective interventions. It is possible that the effects of our patient intervention are underestimated, as the intervention was only received by 75% of eligible patients. Another strength of our study is the novelty of the combined real-time provider teaching and PEMR interventions.

Our study has several limitations. First, the 2019 GOLD guidelines were published after our retrospective analysis of historical control subjects had been

completed and before the intervention period (15). For this reason, we did not assess for a step up in therapy or the maintenance of long-acting therapy in the preintervention historical control patients. The 2019 GOLD guidelines also included guidance to prescribe inhaled steroids to patients with elevated eosinophil counts and to discontinue them in patients with pneumonia, which may have altered the care received by the intervention patients compared with preintervention control subjects (15). This limitation prevented us from drawing further conclusions regarding the inhaler classes on discharge given in Table E2. Considering these limitations, our study shows that real-time provider teaching regarding guideline-directed escalation in therapy can feasibly guide prescription practices, but the extent to which this improves over existing practices should be a subject for further investigation. Second, although Internal Medicine residents were the primary audience for our intervention, we did not collect data on the exact composition of the providers who received our teaching intervention. The total 71 providers included Internal Medicine attending physicians, residents, physician assistants, and subinterns. Third, the novel real-time provider teaching intervention required one of the authors (J.K.K., M.A.S., M.L.T., or M.V.) to be available for teaching on a daily basis. This could make adoption of our model challenging in centers in which a pulmonologist is not always available to perform real-time teaching.

Conclusions

In this single-center quality-improvement study, a novel real-time provider teaching intervention combined with a traditional PEMR intervention improved provider knowledge regarding AECOPD and was associated with increased referrals to pulmonary rehabilitation.

Author disclosures are available with the text of this article at www.atsjournals.org.

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